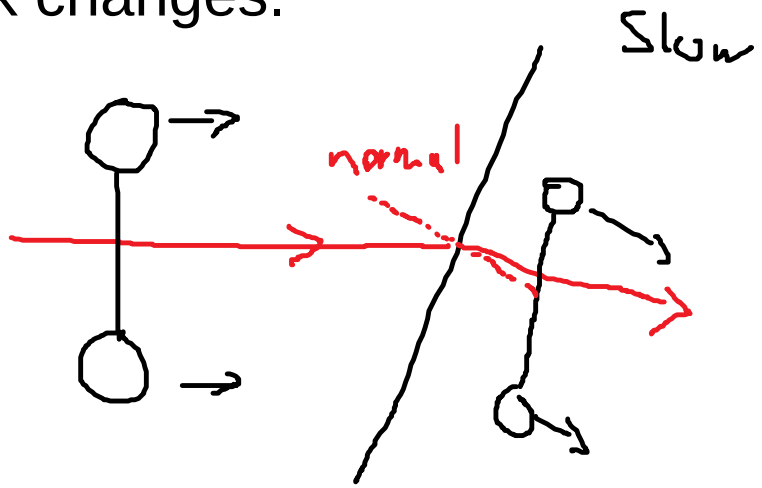
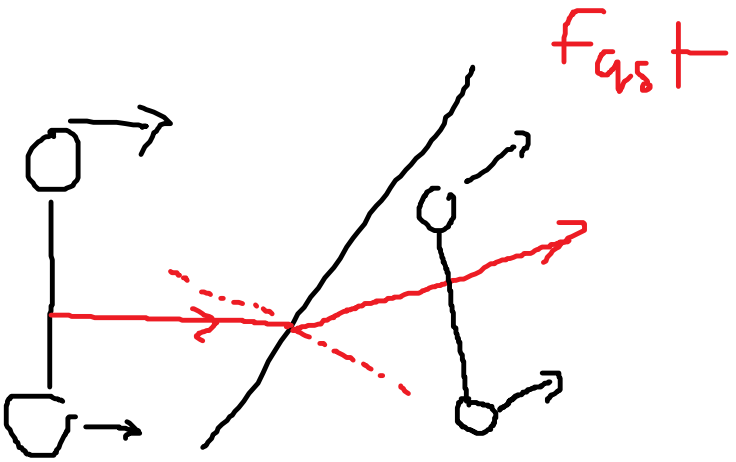
Snell's Law

Demonstration:
Taylor and Ashley holding a metrestick walking at a steady pace are like a wave front (wave crest).
When one of them goes into another medium, their speed changes, so the angle of the metre stick changes.

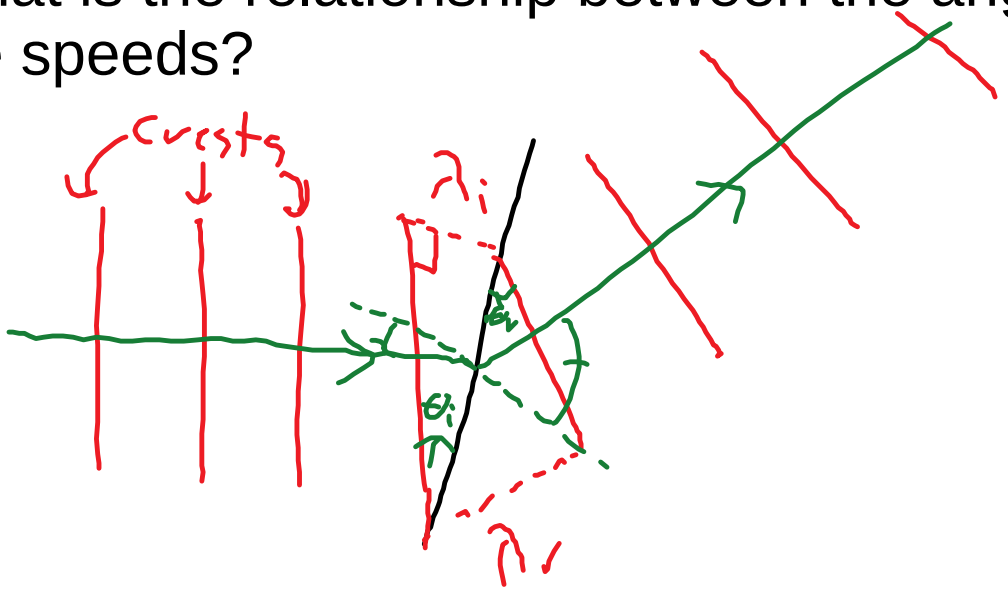


the wave front bends towards the normal as they go at a slower speed.



The wave front refracts away from the normal going into the faster medium

What is the relationship between the angles and the speeds?



common hypotenuse, h

$$\sin\theta_i = \frac{\lambda_i}{h}$$

$$\sin\theta_r = \frac{\lambda_r}{h}$$

$$h = h$$

$$\frac{\lambda_i}{\sin\theta_i} = \frac{\lambda_r}{\sin\theta_r}$$

$v = \lambda f$

$\lambda = (v/f)$

$$\frac{v_i/f}{\sin\theta_i} = \frac{v_r/f}{\sin\theta_r}$$

When you go from one medium to another, the frequency doesn't change, it cancels in the above equation leaving up with:

$v_i/\sin\theta_i = v_r/\sin\theta_r$

$v_i/v_r = \sin\theta_i/\sin\theta_r$

refraction is caused by the change in speed.

speed of light is 3.00×10^8m/s in a vacuum

This is big, so we use a quantity called the index of refraction so we don't have to deal with big numbers.

index of refraction, n = c/v
ratio of the speed of light in a vacuum to the speed of the light in the medium

air n=1.0003 (very close to the speed in a vacuum)
water n=1.33

crown glass n=1.5
diamonds n=2.4

eg. You send a beam of light from air into a block of crown glass, n=1.5 at an angle of 35.0º to the normal.

a) what is the speed of light in crown glass?
b) at what angle will the beam of light go into the glass?
c) draw the beam going in.

$v_i/v_r = \sin\theta_i/\sin\theta_r$ since $n=c/v$ $v=c/n$

$(c/n_i)/(c/n_r) = \sin\theta_i/\sin\theta_r$ $c=c$
$(1/n_i)/(1/n_r) = \sin\theta_i/\sin\theta_r$
$(n_r/n_i) = \sin\theta_i/\sin\theta_r$

$n_i\sin\theta_i = n_r\sin\theta_r$

$n=c/v$

Snell's Law
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a) what is the speed of light in crown glass?
b) at what angle will the beam of light go into the glass?
c) draw the beam going in.

a) $3.0\times10^8 / 1.5 = 2.0\times10^8$ m/s

c) draw the beam going in.

a) $3.0 \times 10^8 / 1.5 = 2.0 \times 10^8 \text{ m/s}$

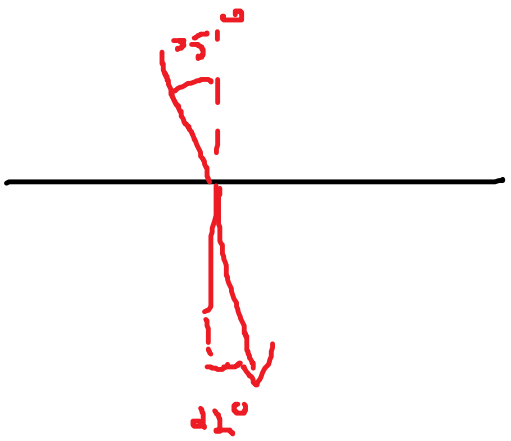
b) $n_1 \sin\theta_i = n_r \sin\theta_r$

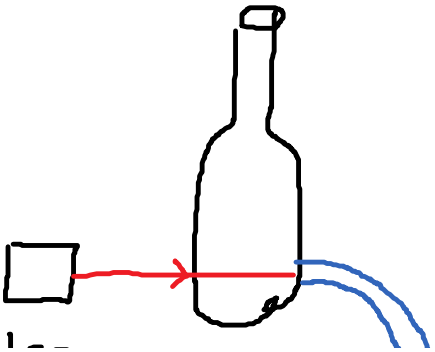
$1.0003(35.0^\circ) = 1.5 \sin\theta_r$

$\theta_r = \sin^{-1} \frac{\sin 35.0^\circ}{1.5}$

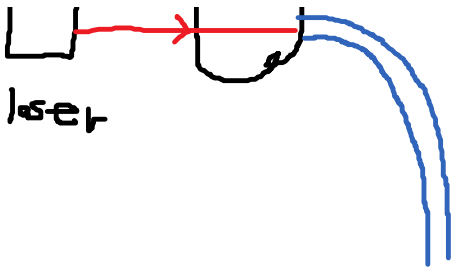
$\theta_r = 22.5^\circ$

Asin((Sin(35xpi/180)/1.5))=
0.407239205824143
0.407239205824143 x180/pi=
23.33308774598285
using calculator = 22.5º





Why does the laser light go down the water stream? I thought it goes in a straight line. what's up?



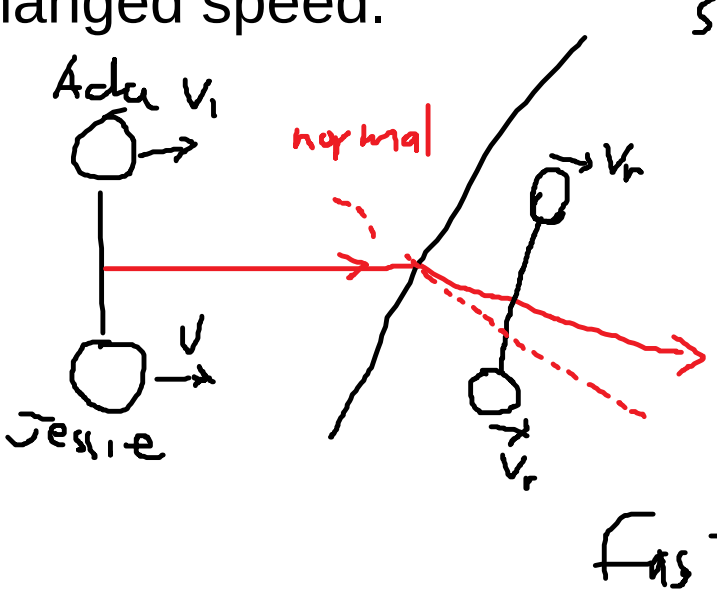
thought it goes in a straight line, what's up?

Refraction - Snell's Law

Lab - you noticed that the light changed direction going from one medium to another. Why?

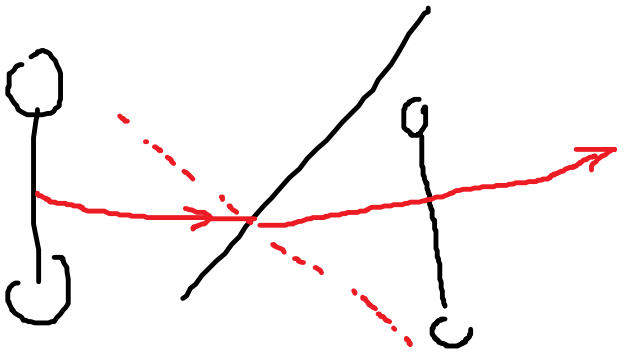
Demonstration

Ada and Jessie walking with a metre stick, modeling a wave front - a wave crest.
When they hit the medium boundary they changed speed.



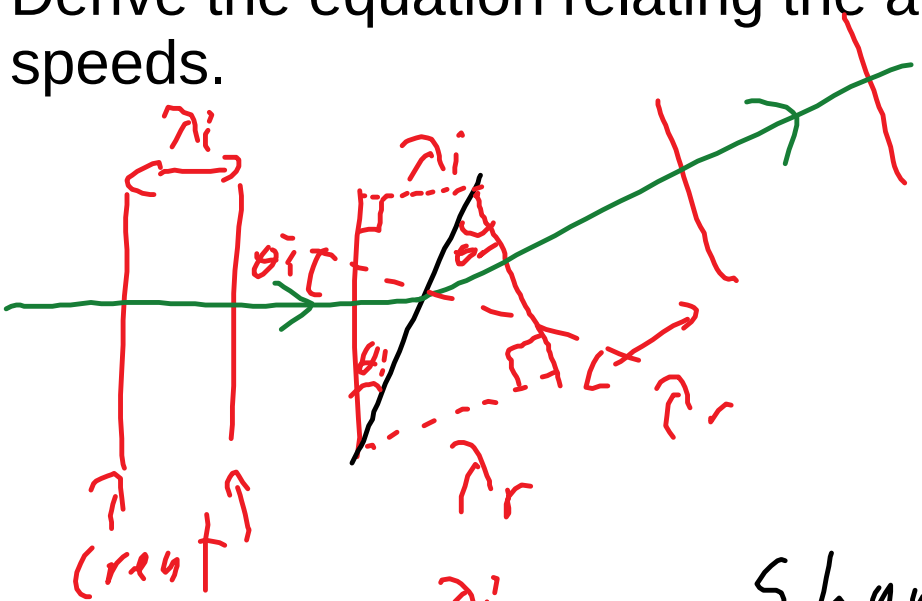
refract towards the

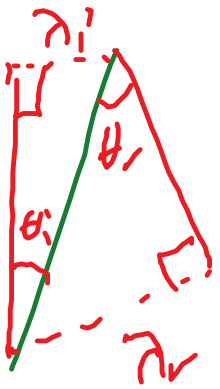
normal



refract away from the normal

Derive the equation relating the angles to the speeds.





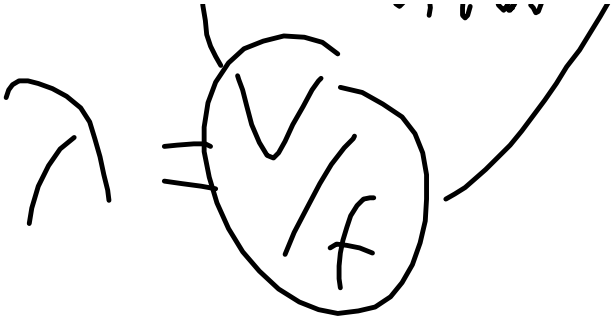
Shared hypotenuse

h

$$\sin\theta_i = \frac{\lambda_i}{h}$$

$$h = h$$

$$\frac{\lambda_i}{\sin\theta_i} = \frac{\lambda_r}{\sin\theta_r}$$



$$\frac{v_i/f}{\sin\theta_i} = \frac{v_r/f}{\sin\theta_r}$$

$$f = f$$

frequency of the wave is the same in each medium - think the energy pulse of each wave has to come from somewhere.

$v_i/\sin\theta_i = v_r/\sin\theta_r$

$v_i/v_r = \sin\theta_i/\sin\theta_r$

refraction is caused by the change in speeds of the wave going from one medium to another.

what is the speed of light?
$c=3.00\times10^8$m/s in a vacuum
that is a big number.
to make it easier, we invent a quantity called

index of refraction, n

$n=c/v$

c is speed of light in a vacuum

v is the speed of light in a medium with index of refraction, n

eg. vacuum n=1 exactly

air n = 1.0003

water 1.33

crown glass n=1.50

diamond n=2.4

$v_i/v_r = \sin\theta_i/\sin\theta_r$ and $n=c/v$

$n=c/v$ $v=c/n$

$(c/n_i)/(c/n_r)= \sin\theta_i/\sin\theta_r$

since c=c

$(1/n_i)/(1/n_r)= \sin\theta_i/\sin\theta_r$

$n_r/n_i= \sin\theta_i/\sin\theta_r$

$n_r\sin\theta_r = n_i\sin\theta_i$ $n=c/v$

This is Snell's Law, i is incident(going in) r is refracted(going through)

eg. You shine a beam of light on a block of crown glass, n=1.50, at 35.0º to the normal.

a) what is the speed of light in crown glass?

b) at what angle will the beam go in the glass block?

c) draw the beam going in.

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